Optimization of Pore Structure in Activated Carbons for High-Performance Methane Storage

Hye-Min Lee[1,†], Byeong-Hoon Lee[1], Seo-Kyong Jeong[1], Byung-Joo Kim[2],

[1]Research & Development Division, Korea Carbon Industry Promotion Agency, Jeonju 54853, Korea

[2]Department of Materials Science and Chemical Engineering, Jeonju University, Jeonju 55069, Korea

([†]leehm@kcarbon.or.kr)

The generation of organic waste resources, such as livestock manure, sewage sludge, and food waste has been continuously increasing due to population growth and industrial development. These organic wastes are converted into biogas through anaerobic digestion processes in biogasification facilities, and the produced biogas is subsequently upgraded to high-purity methane for use as an energy source. However, biogasification facilities are generally located in suburban areas due to land availability requirements and odor-related issues, whereas the major demand for methane is concentrated in urban regions. Therefore, the development of efficient and safe methane storage and transportation technologies is essential for the effective utilization of biogas-derived methane. Among various methane storage technologies, adsorbed natural gas (ANG) storage has attracted significant attention, as it enables methane storage in porous materials under ambient temperature and relatively low pressure (~3.5 MPa). Compared to conventional compressed natural gas (CNG) and liquefied natural gas (LNG) technologies, ANG offers higher energy efficiency and enhanced storage safety. The methane storage performance of porous materials is governed by a high specific surface area and an optimal pore size distribution. Accordingly, most previous studies have primarily focused on activation processes to increase pore development. However, activation strategies aimed solely at maximizing specific surface area often suffer from high activation costs and low production yields, which limit their economic feasibility. Therefore, it is essential to develop porous carbon materials with optimized pore structures that enable high methane storage performance while reducing manufacturing costs.

In this study, coconut-derived activated carbons (CACs) were prepared by chemical activation using KOH with impregnation ratios of 1:2 (CAC-KOH(D2)) and 1:4 (CAC-KOH(D4)) at activation temperatures ranging from 600-900 ℃. In particular, the effects of KOH impregnation ratio and activation temperature on pore development and methane adsorption performance were systematically investigated. As a result, CAC-KOH(D4)-C900 exhibited the maximum specific surface area of approximately 3,120 m^2/g. However, although CAC-KOH(D4)-C700 and CAC-KOH(D2)-C800 showed comparable specific surface areas under similar activation conditions, a higher methane uptake of up to 16 wt.% was observed. Under conditions of equivalent specific surface area, samples with a higher micropore ratio exhibited enhanced methane adsorption performance. Consequently, the overall methane adsorption capacity was found to be more strongly influenced by the micropore fraction around 1 nm than by the specific surface area alone.